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THE ORIGIN OF LAKE ATHABASKA*

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Geological Survey of Canada

Lake Athabaska is the most southerly and the smallest of the three large lakes which drain, by means of the Mackenzie River, into the Arctic Ocean. The general relations of the lake are shown in the diagrammatic map of the Mackenzie Basin, on p. 391. It lies in the physiographic province known as the Laurentian Plateau near the western margin where it borders on the Great Plains. The lake has a length of 205 miles, a maximum width of 35 miles, and an area of approximately 2,850 square miles. Its shore line has a length of over 750 miles; 150 miles longer if the numerous islands be included. The northern shore with its many long, narrow, irregular bays is largely responsible for this excessive length. Here is a youthful shore line produced by the flooding of an uneven land surface.

The southern shore presents a very different set of features. It is dominantly composed of sand beaches resulting from the erosion of the flat-lying beds of Athabaska sandstone which extends along the southern shore of the lake. Back from the shore at the eastern end of the lake the sandstone beds form an escarpment rising in places to a height of 400 feet above the lake. The western half of the southern shore consists of sand beaches, bordered by low sandstone cliffs. Going southward from the lake the ascent is here gradual across a sandy plain to a plateau surface formed upon Athabaska sandstone. On William River the first outcrop of sandstone is encountered 12 miles from the lake. Above this point the ascent is more rapid, the river being marked by short cascades at the edges of outcropping layers of sandstone.

The country surrounding the lake shows the features which are so uniform over the Laurentian Plateau—moderate relief and disorganized drainage. However, the altitude of the upland surface in the neighborhood of Lake Athabaska varies from about 800 feet to 1,300 feet above sea level, a difference of relief which is greater than that shown by much of the plateau. North of the lake the country is a monotonous region of low rocky hills and ridges, separated by depressions which for the most part are occupied by lakes or muskeg swamps. Few of the hills are more than 300 feet in height; they are commonly well rounded on top and are covered with small jack pine, spruce, and poplar. The general trend of the ridges is northeast, and their sides are commonly very steep. This northeast trend is largely due to rock structure. North of the lake both the foliation of the gneisses and the bedding of the Pre-Cambrian sediments have a northeasterly strike, a feature which influenced the preglacial drainage.

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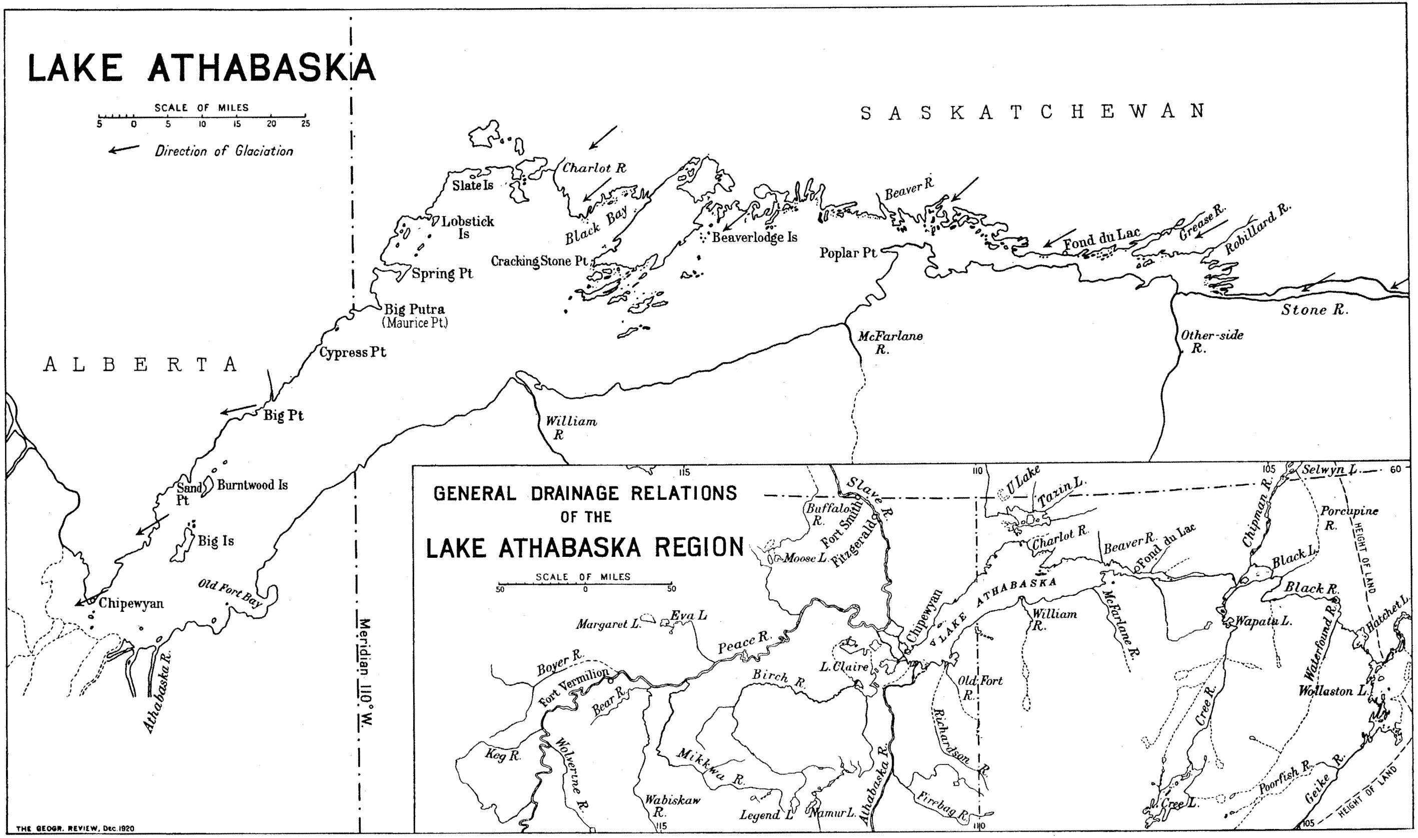

FIG. 1—Outline map of Lake Athabaska. Inset is shown the drainage of the region around the lake. The relation of the lake to the Mackenzie River system as a whole is shown in the diagrammatic map, p. 391.

The present streams of the region, like those of the Laurentian Plateau in general, are marked by lake expansions, rapids, waterfalls, and narrow gorges. Others flow in valleys which are big and wide and out of all proportion to the streams draining them. It is a drainage system which has been completely disorganized by Pleistocene glaciation.

THE ORIGIN OF LAKE ATHABASKA

A basin of the size of that occupied by Lake Athabaska must be explained as due either to tectonic or erosional forces or both. The best criterion which we can employ as to the applicability of the former lies in the structure of the youngest bed-rock formation of the region, the Athabaska sandstone. This is a clastic formation of wide extent which forms outcrops south of Lake Athabaska and exposures of smaller extent along the northern shore. On the southern shore at the eastern end of the lake it forms cliffs, in places 400 feet in height. It lies in an essentially horizontal position. The outcrops on the northern shore in the immediate vicinity of the lake likewise are flat-lying. The fact that there are no prevailing dips towards the lake on either side points to an absence of control by folding for the formation of the basin. The extreme irregularity of the northern shore and great variations in the width of the basin also suggest a lack of control by faulting.

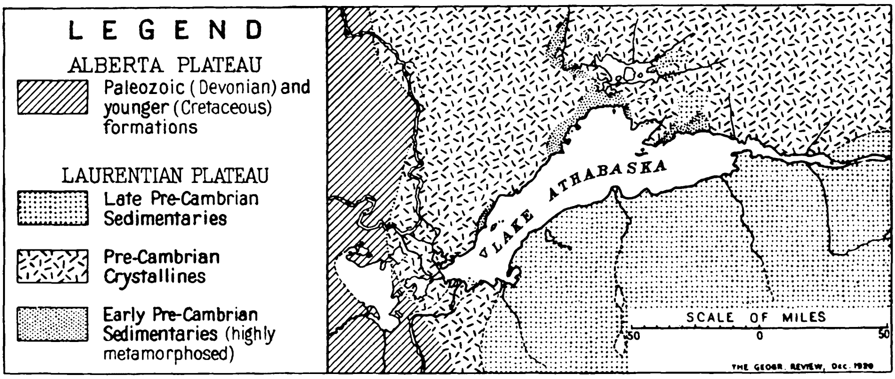
LEGEND
ALBERTA PLATEAU
Paleozoic (Devonian) and younger (Cretaceous) formations
LAURENTIAN PLATEAU
Late Pre-Cambrian Sedimentaries
Pre-Cambrian Crystallines
Early Pre-Cambrian Sedimentaries (highly metamorphosed)
LAKE ATHABASKA
SCALE OF MILES
50
0
50
THE GEOGR. REVIEW, DEC. 1920

FIG. 2—Geological relationships in the Lake Athabaska area (from the Geological Map of the Dominion of Canada, 1913, scale 1:6,336,000, and the map of the Mackenzie River Basin accompanying Geol. Survey of Canada Memoir 108, 1919, scale 1:3,100,000). The lake which lies on the edge of the Laurentian Plateau occupies a glacially eroded depression at the contact of Pre-Cambrian crystallines and late Pre-Cambrian sedimentaries.

It may also be inferred from the character of the preglacial topography that the basin is due to glacial rather than structural control. The present low relief displayed over the Laurentian Plateau is an inheritance from Pre-Ordovician times. A study of the profiles at the base of the Ordovician sediments, which still overlap the Pre-Cambrian rocks in the Hudson Bay-James Bay region and along the southwestern margin of the plateau northwest of Lake Winnipeg, shows that the surface upon which the advancing Ordovician sea deposited its sediments was a clean surface of extremely

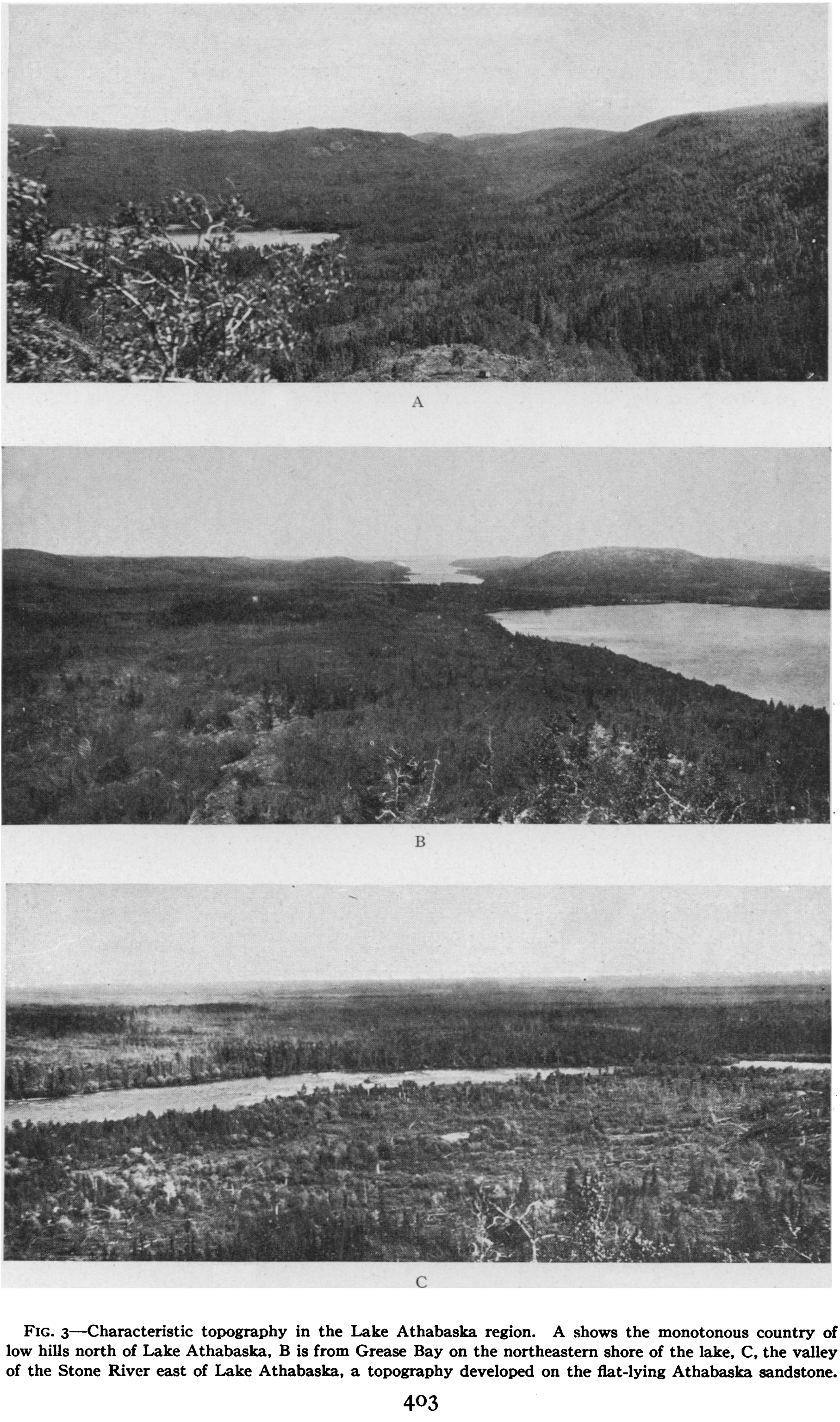

FIG. 3—Characteristic topography in the Lake Athabaska region. A shows the monotonous country of low hills north of Lake Athabaska, B is from Grease Bay on the northeastern shore of the lake, C, the valley of the Stone River east of Lake Athabaska, a topography developed on the flat-lying Athabaska sandstone.

low relief with only minor irregularities. It may be inferred that in Pre-Ordovician times the Canadian shield was base-leveled, and its wide extent suggests that the process was by means of subaerial agencies. In the advanced physiographic stage which the region had attained lakes would be absent, for long before this condition had been reached any lakes would have been drained or filled. Even if part or all of the region was subsequently covered by mantles of Palaeozoic or Cretaceous sediments, the long erosion of Tertiary time would have effected similar conditions. It may be accepted that in preglacial times there was no lake or basin where Lake Athabaska now lies.

It is permissible to conclude, therefore, that the basin of Lake Athabaska is due to glacial causes, either erosional or depositional. It is extremely probable that the main preglacial drainage was much like what it is today. The line separating the Athabaska series from the older rocks on the north very probably marked a wide preglacial valley which drained as now to the Mackenzie. The enlargement of such a valley by glacial erosion or its damming by glacial deposition or a combination of these two factors would most readily explain the formation of the lake basin. No evidence of a morainal dam, however, exists. The western end of the lake is low-lying and is the meeting point of a number of rivers, the Athabaska from the south, the Peace from the west, and the Birch from the southwest—a set of conditions difficult to explain on the theory of a dam.

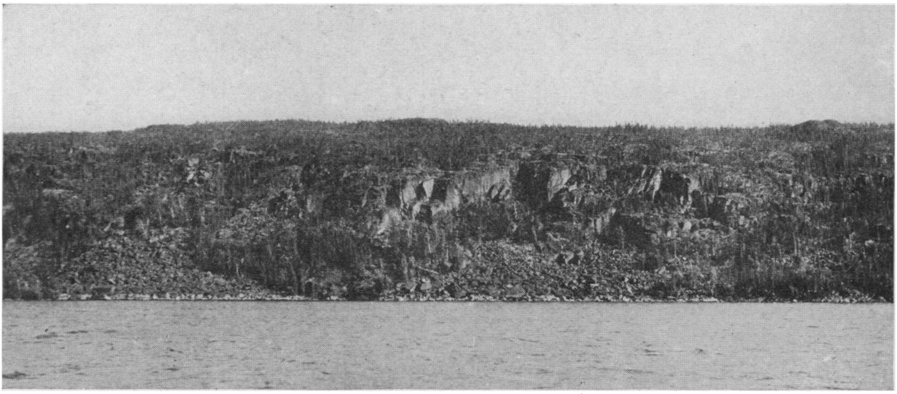

FIG. 4—A typical rock cliff, north shore of Lake Athabaska.

The alternative theory of a basin produced by ice erosion involves the question whether ice is able to erode rock. In the Athabaska region evidence of ice erosion is found in the rounded hills and islands and smoothed sides of channels, where the erosion is by molding and smoothing, and in many definite examples by the plucking of blocks of rock along joint planes. The latter is here probably the most important type of glacial work. A further way in which ice erosion has been accomplished is by the uniting of pot-holes, a process which was definitely located north of Lake Athabaska.

Some of the minor features of the topography of the northern shore also bear on the problem of glacial erosion. The prevailing trend of the embayments is in a northeasterly direction along the line of glaciation. The prevailing trend of many of these narrow bays parallel to the direction of glaciation and their deep V-shaped cross section is strongly suggestive of glacial erosion.

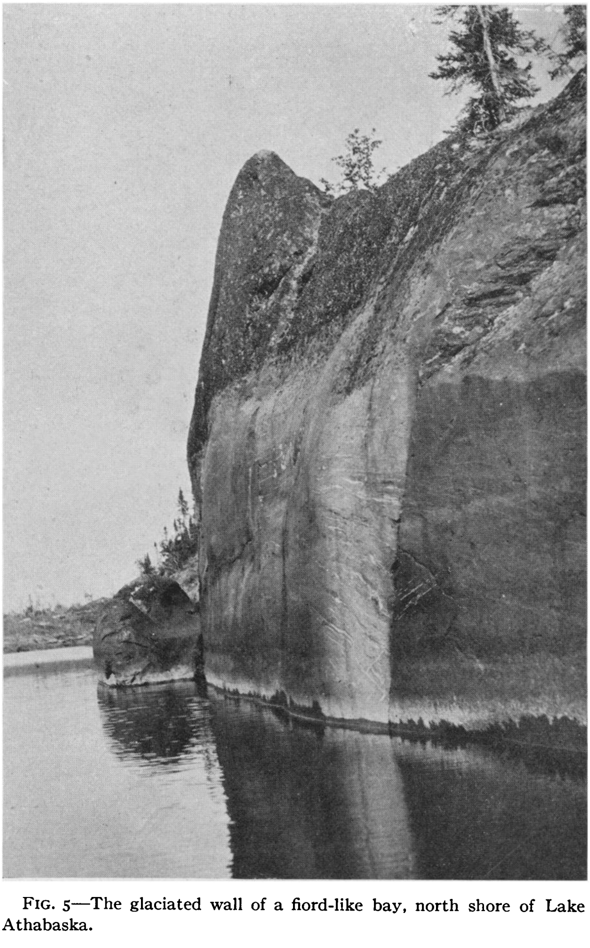

FIG. 5—The glaciated wall of a fiord-like bay, north shore of Lake Athabaska.

The general character of the lake is also significant of its glacial origin. A study of the striation directions plotted on a map of the region shows that the lake is widest and deepest where it lies parallel to the direction of glacial movement. The wide middle and western parts of the lake run in a southeasterly direction, while the narrow eastern part maintains a westerly direction at a considerable angle to the regional glaciation. These facts suggest that the preglacial Stone River flowed where Lake Athabaska now lies, that is, in a westerly direction to about the region of Black Bay and then in a generally southwesterly direction. Where the ice moved directly down the valley the greatest amount of erosion was accomplished.

The amount of erosion which the Pleistocene glaciers accomplished in the valley in which Lake Athabaska now lies cannot be estimated accurately, but that it both widened and deepened the valley is fairly certain. The steep cliffs of sandstone on the southern shore and the equally abrupt cliffs of crystalline rocks on the northern coast in the narrow eastern part of the lake are not features which mark a mature valley in an old age of topographical development, and they can most easily be explained by lateral glacial plucking.

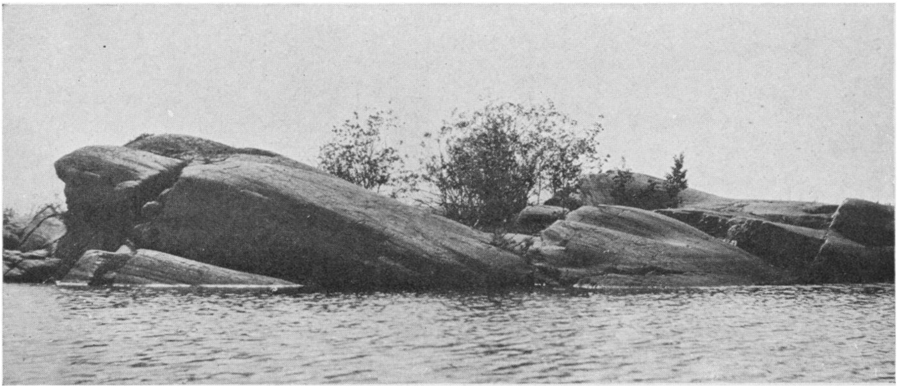

FIG. 6—An illustration of glacial plucking.

To what extent the basin of Lake Athabaska was deepened by glacial erosion involves a consideration of the depth of the lake. In many places the rocky coasts run down steeply under the water, and the impression that one gets is that the lake is deep. The only available record of sounding made in the lake is found on a map of Canada published in 1880 showing the country to be traversed by the Canadian Pacific Railway. At one place in Black Bay the depth is given as 32 fathoms, and at another place the words "no bottom" evidently indicate a considerably greater depth. A depth of 300 feet is probably a conservative estimate for the maximum depth of Lake Athabaska.

The preglacial Stone River certainly did not flow 300 feet below the present level of Lake Athabaska. It probably flowed at or even above the present level of the lake. This may be shown from the streams which empty into the lake. All flow over bed rock at no great distance from their mouths. This is true of the Stone River and all the smaller streams north of Lake Athabaska. The Athabaska River flows over Devonian limestone whose outcrop may be traced along the river to the head of the delta. On the Quatre Fourches Channel the presence of outcrops of granite gneiss shows that bed rock is at but a shallow depth below the river. Again at Fitzgerald on the Slave River, the outlet of Lake Athabaska, an exposure of granite gneiss extends completely across the river, forming a rapid at an elevation of about 80 feet below that of Lake Athabaska. If the latter has a depth, therefore, of 80 feet its basin could not have been produced by a river flowing out down the channel of the Slave River.

It may be concluded that the basin of Lake Athabaska was deepened to the extent probably of 200 feet. How much of this was due to the removal of disintegrated material and how much of it was hard rock is impossible to determine. The general low relief of the region suggests, however, that most of it was hard rock such as is now exposed thereabouts.

As a further test of the validity of the argument of the production of basins by glacial erosion, a study of the other large lakes of the region such as Great Slave Lake and Great Bear Lake might be made. Unfortunately, however, the information regarding these lakes is very meager. In a general way however, they favor the conclusion made for Lake Athabaska. They are not structural basins, as is shown by the general flat-lying nature of the Devonian and Mesozoic strata exposed in places along their shores. Their bays for the most are likewise parallel to the direction of glaciation.

> The evidences of glaciation are well marked around Great Slave Lake. The general course of the striations is southwestward in conformity with the longer diameter of the lake basin, but it varies locally, the movements of the glaciers having adapted themselves to the trend of each bay or channel which approximated to that of the general course followed by the ice.[1]

This has recently been confirmed by A. E. Cameron. Speaking of the northern shores of Great Slave Lake, he says:

> The entire shore line shows clearly the effects of excessive glacial action. Many deep narrow bays stretch inland approximately parallel to one another in a direction about south 60 degrees west (magnetic) or north 80 degrees west (astronomical). That this direction is parallel to the glacial movement is shown by well marked striae on Windy Point.[2]

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[1] Robert Bell: Mackenzie District, *Summary Rept. Geol. Survey of Canada*, 1899, pp. 103 A–110 A; reference on p. 109 A.

[2] A. E. Cameron: Reconnaissance on Great Slave Lake, North West Territories, *Summary Rept. Geol. Survey of Canada*, 1916, Ottawa, 1917, pp. 66–76; reference on p. 69.